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Physics 30

Diploma Examination Results
Examiners' Report for June 1996

The summary information in this report provides teachers, school administrators, students, and the general public with an overview of results from the June 1996 administration of the Physics 30 Diploma Examination. This information is most helpful when used with the detailed school and jurisdiction reports that have been mailed to schools and school jurisdiction offices. An annual provincial report containing a detailed analysis of the combined January, June, and August results is published each year.

Description of the Examination

The Physics 30 Diploma Examination consists of 37 multiple-choice questions worth 52.9%, 12 numerical-response questions worth 17.1%, and two written-response questions worth 30% of the total examination.

Achievement of Standards

The information reported is based on the final course marks achieved by 4 884 students in Alberta who wrote the June 1996 examination.

- 90.7% of the 4 884 students achieved the acceptable standard (a final course mark of 50% or higher).
- 27.7% of these students achieved the standard of excellence (a final course mark of 80% or higher).

Approximately 36.4% of the students who wrote the June 1996 examination were females.

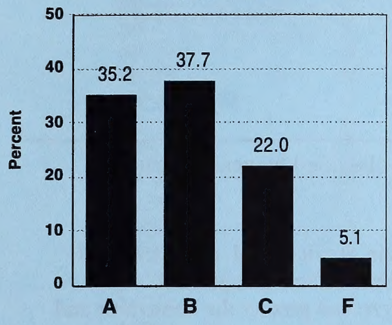
- 93.6% of these students achieved the acceptable standard (a final course mark of 50% or higher).
- 25.2% of these students achieved the standard of excellence (a final course mark of 80% or higher).

Approximately 63.6% of the students who wrote the June 1996 examination were males.

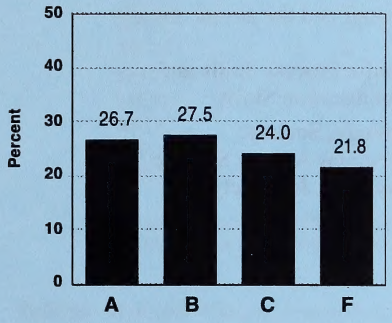
- 89.7% of these students achieved the acceptable standard (a final course mark of 50% or higher).
- 29.2% of these students achieved the standard of excellence (a final course mark of 80% or higher).

Students have demonstrated a noticeable improvement in their ability to communicate their solution to the open-ended written-response problem. Students are still experiencing difficulty with two dimensional momentum problems and calculations that involve algebraic manipulation of variables.

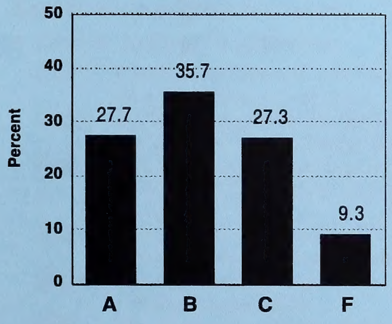
School-Awarded Mark



Diploma Examination Mark



Final Course Mark



Students First!
Student Evaluation

Alberta
EDUCATION

Provincial Averages

- The average school-awarded mark was 72.3%.
- The average diploma examination mark was 65.2%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 69.0%.

Approximately 6.2% of the students who wrote the examination in June 1996 and received a school-awarded mark had previously written at least one other Physics 30 Diploma Examination during the June 1995 to June 1996 period. This sub-population (303) achieved an examination average of 54.9%, compared with 65.2% for the population (4 884) who first wrote a Physics 30 examination in June 1996. The group of students who rewrote increased their overall average by 4.9%.

Results and Examiners' Comments

This examination has a balance of question types and difficulties. It is designed so that students achieving the acceptable standard will obtain a mark of 50% or higher, and students achieving the standard of excellence will obtain a mark of 80% or higher.

In the following table, diploma examination questions are classified by question type: multiple choice (MC), numerical response (NR), and written response (WR). The column labelled "Key" indicates the correct response for multiple-choice and numerical-response questions. For numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer. For multiple-choice and numerical-response questions, the "Difficulty" indicates the proportion (out of 1) of students answering the question correctly. For written-response questions, the "Difficulty" is the mean score achieved by students who wrote the examination.

Questions are also classified by general learner expectations.

Knowledge:

GLE 1	Explain gravitational, electrical, and magnetic effects on systems
GLE 2	Analyze and predict the behaviour and physical interactions of objects
GLE 3	Describe and analyze resistive circuits and the function of EM devices
GLE 4	Solve problems related to EM wave behaviour and the atomic theory

Skills:

SPSC	Scientific Process Skills and Communication Skills

Science, Technology, Society:

STS	Connections Among Science, Technology, & Society

Blueprint

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPSC	STS
MC1	C	0.874		√				√
MC2	C	0.673		√				√
MC3	B	0.870			√		√	√
MC4	B	0.833		√				√
MC5	A	0.835		√				√
NR1	1.26	0.800				√		√
MC6	B	0.485				√	√	√
MC7	C	0.796				√		√
MC8	C	0.739		√				√
NR2	1.24, 1.25	0.550		√				√
NR3	4.52, 4.53	0.578		√				√
MC9	A	0.600		√				√
MC10	B	0.734	√					
MC11	B	0.574		√				
NR4	4.64, 4.63, 4.62	0.336		√				√
MC12	C	0.723			√			
MC13	C	0.650			√			√
MC14	B	0.557			√			√

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPSC	STS
NR5	2.32	0.532			√			
MC15	D	0.679			√		√	
MC16	C	0.771	√					
MC17	B	0.556	√				√	√
MC18	D	0.647	√					
MC19	B	0.552		√			√	
NR6	7.89	0.499				√	√	
NR7	1.77*	0.608		√				√
MC20	D	0.443		√			√	
MC21	C	0.883				√		
MC22	A	0.663		√			√	√
MC23	B	0.751				√	√	√
MC24	C	0.899				√		
MC25	D	0.907				√	√	
NR8	1.22	0.794				√		
MC26	C	0.861				√		
MC27	**							
MC28	B	0.793				√	√	
MC29	B	0.520				√		
MC30	A	0.321				√		
MC31	B	0.769				√		
NR9	2119	0.770		√				
MC32	C	0.601		√			√	√
NR10	14.5, 14.6	0.639				√		√
MC33	C	0.643			√		√	
MC34	D	0.356		√			√	√
NR11	1.51	0.810		√				
MC35	B	0.870				√		
NR12	3.02, 3.04, 3.03	0.754				√		
MC36	A	0.726		√				
MC37	A	0.747	√				√	
WR1		0.682		√			√	√
WR2		0.552	√					√

* The algorithm for NR7 IS NR7 = $(NR6)^2(0.0285)$
** MC27 was dropped from the examination

Subtest: Multiple Choice, Numerical Response, and Written Response (Average by Subtest)

When analyzing detailed results, please bear in mind that subtest results **cannot** be directly compared. Results are in average raw scores.

- General Learner Expectations:

GLE 1	Explain gravitational, electrical, and magnetic effects on systems	9.0	out of	15
GLE 2	Analyze and predict the behaviour and physical interactions of objects	18.9	out of	30
GLE 3	Describe and analyze resistive circuits and the function of EM devices	4.7	out of	7
GLE 4	Solve problems related to EM wave behaviour and the atomic theory	12.3	out of	17
Skills	Scientific process and communication skills	17.0	out of	27
STS	Connections in science, technology, and society	26.2	out of	42

- Multiple choice and numerical response: 32.6 out of 48
  Multiple choice: 24.9 out of 36
  Numerical response: 7.7 out of 12

- Written Response: 12.3 out of 21
  Question 1: 6.8 out of 11***
  Communication: 2.0 out of 3
  Content: 4.7 out of 8
  Question 2: 5.5 out of 10

*** Individual student scores for Question 1 are equal to the Scale 1 score added to the Scale 2 score, then rounded to a whole number.

Food preservation is an ongoing human concern. A new technology, food irradiation, preserves food by destroying parasites and micro-organisms, and inhibiting sprouting. This is accomplished by passing the food through a thick-walled chamber containing a source of radiation such as Cobalt-60 that produces gamma rays. The half-life of Cobalt-60 is 5.3 years.

26. In 1994, a new Cobalt-60 unit could irradiate 10 000 kg of potatoes per day. By the year 2010, the rate of flow of potatoes through this unit should be reduced to about

A. 5000 kg per day
B. 2500 kg per day
•C. 1200 kg per day
D. 600 kg per day

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34. A group of hydrogen atoms are in the excited $n = 4$ state. As they drop to the ground state, the maximum number of **different** wavelengths of photons that could be emitted is

A. 1
B. 2
C. 4
•D. 6

Numerical Response

8. According to Einstein (1905), mass defect can be explained by assuming that an equivalent amount of energy is carried away by an energetic photon. The amount of energy equivalent to the mass defect could be predicted by the famous equation $E = mc^2$. Assuming that the mass defect is 9.00×10^{-30} kg, the frequency of the photon that corresponds to that energy, expressed in scientific notation, is $b \times 10^w$ Hz. The value of b is __________ .

(Round and record your answer to three digits.)

Answer: **1.22**

Multiple-Choice and Numerical-Response Questions

The following questions were selected for discussion because they exemplify what is required to achieve the acceptable standard and the standard of excellence.

Multiple-choice question 26: Most students were able to recognize that the process described in the information box was an example of radioactive decay and were then able to apply their knowledge of half-life to calculate the final flow of potatoes. Of students who were unsuccessful in answering this question correctly, the majority chose alternative B. In most cases, this was probably the result of a miscalculation of the number of decay periods.

A total of 86.1% of the students answered this question correctly. Of the students who achieved the standard of excellence, 97.9% answered correctly, and of those students who achieved the acceptable standard but not the standard of excellence, 89.9% were correct in their response. In addition, 62.6% of the students who did not achieve the acceptable standard chose the correct answer.

Multiple-choice question 34: The results on this question were lower than expected with only 35.6% of students answering correctly. In order to solve this question, students needed to recognize that as hydrogen atoms drop from n=4 to ground state, a number of intermediate emissions are possible. The most common incorrect response of "C," 4 different wavelengths, suggests that students are considering emissions originating at n=4 only and have neglected to include emissions that originate from n=3 or n=2. More students chose alternative "C" than the correct response "D."

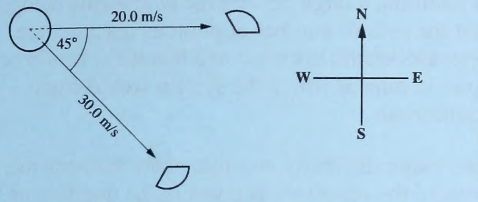
On this question, 58.4% of the students who achieved the standard of excellence selected the correct answer, while only 31.6% of those students achieving the acceptable standard but not the standard of excellence were able to successfully answer the question. Only 17.0% of the students who failed to achieve the acceptable standard answered this question correctly.

Numerical-response question 8: This question was well answered. A total of 79.4% of students calculated the correct answer. Although the question required a second calculation, most students experienced little difficulty in performing the substitution to find the required frequency. The most common error occurred when students apparently did not square the value of "c" in $E = mc^2$.

Of the students who achieved the standard of excellence, 94.4% solved this question correctly, as did 83.8% of the students who achieved the acceptable standard but not the standard of excellence. It is encouraging to see that 50.4% of the students who did not achieve the acceptable standard were able to complete the question correctly.

Use the following information to answer the next two questions.

A stationary bomb exploded in a street in the centre of a city. The three pieces of debris from the bomb, each of approximately the same mass, flew off horizontally in different directions. Analysis revealed that one piece moved east at 20.0 m/s, and a second piece moved southeast at 30.0 m/s.



11. The third piece of debris was difficult to locate. Where should investigators look for the third piece?

A. 27° W of N
•B. 27° N of W
C. 22.5° S of W
D. 22.5° N of E

Numerical Response

4. The speed of the third piece, expressed in scientific notation, is $b \times 10^{w}$ m/s.. The value of b is ___________.
(Round and record your answer to three digits.)

Answer: **4.64, 4.63, 4.62**

Multiple-choice question 11: Approximately 58% of students used their knowledge of conservation of momentum to solve this question correctly. Some selected the correct response by eliminating alternatives that did not "fit" what they visualized would happen in the explosion. Other students drew a vector diagram or resolved the vectors into components and solved for the required angle.

On this question, 83.8% of the students who achieved the standard of excellence responded correctly, while 53.0% of those achieving the acceptable standard but not the standard of excellence selected the correct response. Of the students who failed to achieve the acceptable standard, 35.6% answered the question correctly.

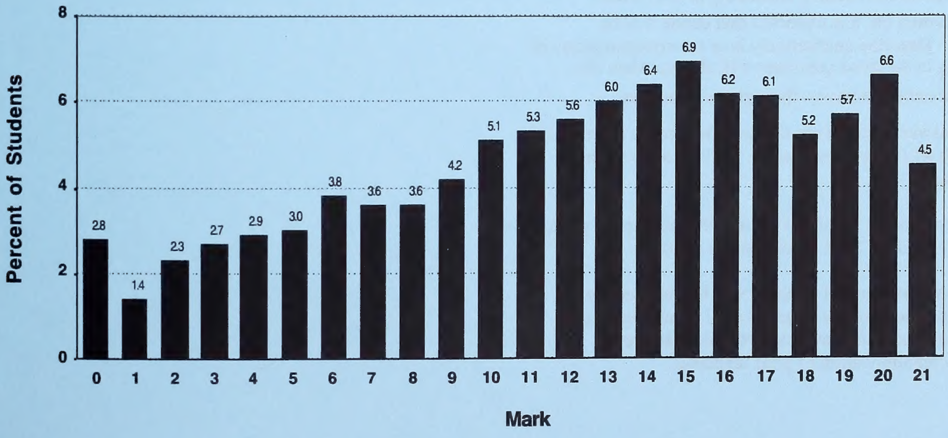
Numerical-response question 4: In order to solve this question, students needed to combine their knowledge of conservation of momentum and two-dimensional collisions with the appropriate trigonometric calculations to obtain the correct value for velocity. Only 33.6% of students were successful in completing this question. The multi-stage nature of this type of problem continues to prove difficult for students.

On this question, 73.8% of the students who achieved the standard of excellence completed the question correctly, while only 24.0% of those achieving the acceptable standard but not the standard of excellence were correct. Of the students who did not achieve the acceptable standard, 6.2% answered correctly.

Written-Response Questions

Of all the students who wrote the exam, 64.4% received a mark of 11 or higher out of 21. The average mark on the written-response questions was 12.3 or 58.6%.

Distribution of Marks for Written Response



Written Response – 11 marks

Applied Physics

Ozone, O_3, is naturally produced and decomposed in Earth's upper atmosphere. It is well established that ozone acts as a filter for much of the ultraviolet radiation that impacts on Earth. The production and decomposition of ozone can be described by the reactions in the following cycle.

I. O_2 + photon energy greater than 8.25×10^{-19} J yields $2\,O$
II. $O + O_2$ in the presence of a catalyst yields O_3
III. O_3 + photon energy in the range of 6.22×10^{-19} J to 7.10×10^{-19} J yields $O_2 + O$

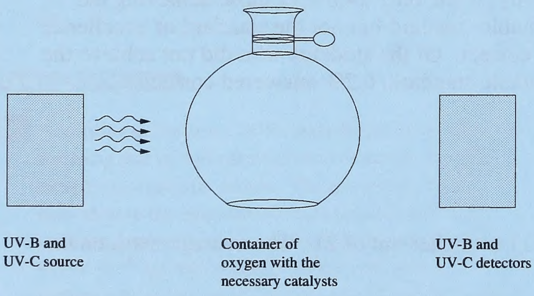
A different ozone decomposition reaction results from the presence of certain substances such as chlorofluorocarbons in the upper atmosphere.

$O_3 + O$ in the presence of CFC's yields $2\,O_2$

A decrease in the ozone layer may cause an increase in the amount of skin cancer in humans.

To study the production of ozone and its ability to filter out (absorb) harmful UV radiation, students filled a glass container with pure oxygen (O_2) and passed UV radiation through the container.

The average wavelength for UV-B is 300 nm and for UV-C it is 240 nm. To verify reactions I, II, and III, the following simulation was designed.



1. After the ultraviolet source consisting of UV-B and UV-C is turned on, it is expected that ozone will be produced. Describe qualitatively how the concentrations of O_2 and O_3 in the glass container will change when the ultraviolet radiation passes through the container.

In your answer, state which radiation will cause reaction I and which will cause reaction III. Include any relevant calculations.

In addition, discuss qualitatively how the number of photons of UV-B and UV-C will change at the detectors.

Note: A maximum of 8 marks will be awarded for the physics used in your answer. A maximum of 3 marks will be awarded for the effective communication of your response.

Written-response question 1 was well answered. Students are becoming more proficient at expressing their ideas and organizing their thoughts. In general, most students were able to make the calculations necessary to determine that Reaction I would be caused by UV-C and Reaction III would be caused by UV-B. In addition, a large percentage of students recognized that the overall number of photons reaching the detectors would decrease and that there would be a point in time at which the system would reach equilibrium.

One major difficulty was that many students merely restated the reactions as given in the question and did not address the concentrations of O_2 and O_3. Another common problem was that many students did not address all three components of the question.

Some common misconceptions that appeared frequently include confusion between alpha and beta radiation and ultraviolet radiation; the belief that a loss of energy is associated with a loss of intensity; and a lack of understanding that the photons are absorbed by the O_2 molecules not scattered, deflected, or defracted.

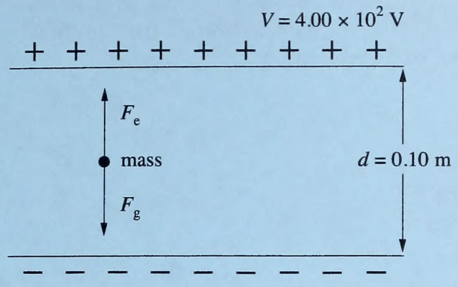
Of the students who achieved the standard of excellence on the exam, 86.3% received 9 out of 11 or better on this question.

On this question, 74.6% of the students who achieved the acceptable standard but not the standard of excellence received 6 out of 11 or better.

On this 11 mark question, the average was 6.7 or 60.9%,

Written Response – 10 marks

A Millikan Experiment



A charged particle that has a mass of 2.8×10^{-16} kg accelerates upward at 3.6 m/s^2 in the electric field between two horizontal plates that have a separation of 0.10 m. The potential difference across the plates is 4.0×10^2 V. The experiment is performed on Earth's surface at sea level.

2. a. Calculate the magnitude and direction of the electric force exerted upon the particle.

b. Determine the charge on the particle. (If you were unable to answer part **a**, use the hypothetical value $F_e = 2.6 \times 10^{-15}$ N.)

c. Determine the time required for the particle to move from the lower to the upper plate when the particle begins at rest.

d. Assume that the voltage applied to the plates can be varied. Calculate the minimum voltage needed to move the particle from the lower plate to the upper plate. (If you were unable to answer part **b**, use the hypothetical value 9.6×10^{-19} C as the charge on the particles.)

e. Assume now that the particle is initially at rest between the plates. If the charges on the plates were inverted (negative plate becomes positive, and positive plate becomes negative), what would be the magnitude and direction of the net force on the particle?

Written-response question 2 had an average of 5.5 out of 10 or 55%. Most students used the proper formulas in their responses to calculate the charge on the particle in part **b** and to find the value of Δt (using kinematics) in part **c**. In most cases, their responses were well organized and sequential, equations were explicitly stated, and significant digits were used correctly.

Often students experienced difficulty with part **a** where $F_e = ma$ was used instead of $F_{net} = ma$. Similarly in part **e**, many students did not show that they were finding F_{net}. Students who attempted to solve part of the problem using energy methods frequently forgot the gravitational energy component. In many responses, it became evident that students do not understand that Millikan forces can be balanced or unbalanced. A further weakness in student responses was their description of the direction of the force (into the page, north, clockwise, etc.).

On this question, 78.9% of the students who achieved the standard of excellence on the exam received a mark of 8 out of 10 or better.

Of the students who achieved the acceptable standard but not the standard of excellence, 63.4% scored 5 out of 10 or better on this question. Only 1% of students did not attempt this question.

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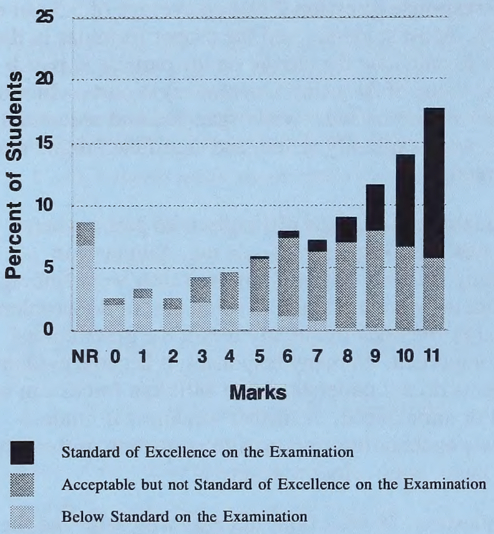
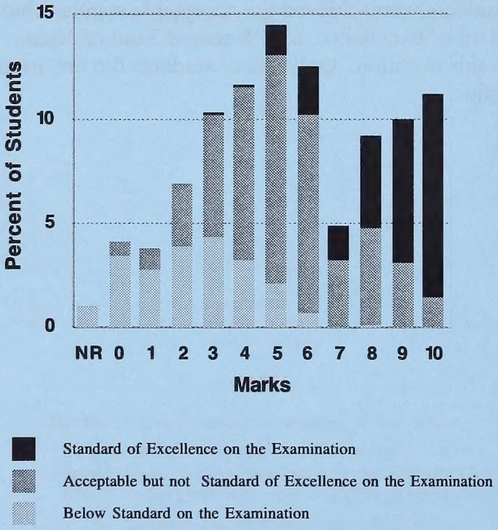
Distribution of Marks for Question 1



Distribution of Marks for Question 2



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